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RHIZOCTONIA DISEASES AND THEIR MANAGEMENT IN CEREALS

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INTRODUCTION

Rhizoctonia root rot has been one of the major impediments to the adoption of minimum- and no-till planting of wheat and barley in the Pacific Northwest and elsewhere. New information on the epidemiology of *Rhizoctonia* species affecting cereals has led to the development of management strategies with the potential to effectively control this disease.

Wheat and barley can be infected by several species of *Rhizoctonia,* including *R. solani*, *R. oryzae*, *R. zeae*, *R. cerealis*, *Rhizoctonia* (W-AK), and many "binucleate" types. The *Rhizoctonia* genus is highly variable. For example, the species *R. solani* is composed of more than a dozen sub-groups of closely related fungi that differ in many physical and behavioral characteristics including: temperature preference, species of plants attacked, types of plant tissue attacked, and regions of occurrence. Symptoms caused by species of *Rhizoctonia* include seed rot, preemergence damping-off, root rot, and foliar blight. Root rot usually has a greater impact on plant health than diseases of other plant tissues.

CAUSAL AGENTS AND SYMPTOMS

Root Diseases

Root diseases caused by *Rhizoctonia* species have been given names such as Rhizoctonia root rot, Rhizoctonia patch, bare patch, stunted patch, barley stunt, purple patch, and crater disease. Different names are used in different countries and regions. Rhizoctonia root rot and bare patch are names used in the Pacific Northwest.

R. *solani* AG-8 is generally considered the primary causal agent of root rot in the Pacific Northwest, South Australia, New South Wales (Australia), and the United Kingdom. *R. oryzae* can also cause significant damage in the Pacific Northwest. Species and groups that cause root rot of wheat and barley in other regions include *R. solani* AG-4 and AG-5 in Texas, *R. zeae* in Minnesota, and *Rhizoctonia* (W-AK) in Alaska. In West Australia the disease is caused by a complex of fungi composed of multiple types of *Rhizoctonia* spp., including *R. solani* AG-2-1, AG-2-2, and AG-8, other *Rhizoctonia* species, and other fungi. A complex of fungi, as opposed to a single pathogen, is thought to cause the bare patch phase of this disease. *Rhizoctonia* is considered a transient species in a rapidly evolving succession of root infecting and colonizing fungi. Australian scientists reported that combinations of fungi in the succession caused more severe root disease than the same fungi used singly. This complexity complicates our ability to manage this disease.

Severe root rot is characterized above ground by the development of circular patches of stunted and/or chlorotic plants that produce little or no grain. This is called the "bare patch" phase of Rhizoctonia root rot. When disease pressure is high, patches may coalesce to create uniform disease development across the entire field. Plants in these fields have uniformly poor vigor and density. Where this occurs the term

Rhizoctonia root rot seems most descriptive, because there are no bare patches to suggest that root disease may be causing the poor performance of the crop. Low disease pressure results in individual stunted plants interspersed within rows of productive plants, or minor root rot characterized by infections that do not cause stunting or other symptoms of reduced plant vigor. Moderate root damage can delay crop maturation up to three weeks without stunting plants.

Symptoms on roots depend on the type of *Rhizoctonia* attacking the roots. Infection by *R. solani* AG-8 results in the development of sunken brown lesions, and as growth of the fungus progresses, roots may be girdled and severed with the remaining root stub having a “spear-tip” appearance. This is most prevalent on crown (secondary) roots. Some isolates of *R. ozyzae* also cause these symptoms at high soil temperatures (>70^{o}F), but at lower temperatures (<60^{o}F) cause yellowing and necrosis (death) of the cortex (tissue between the root’s vascular system and outer surface) without severing the vascular system. As such, *R. ozyzae* is most damaging to crown roots at high temperatures. *R. oryzae* and *R. cerealis* can also retard or prevent development of seminal (primary) roots and lateral branches off main roots, a phenomenon that is not caused by *R. solani* AG-8.

Damage to wheat and barley roots is often dependent on interactions among the specific fungal isolates and temperature. A distribution in disease severity, from none to severe, was observed for 19 isolates of *R. oryzae* tested separately on wheat seedlings at Pullman. Some isolates were more damaging at high temperature and others were equally damaging at all temperatures tested. Similar results were found with 21 isolates of *Rhizoctonia* (W-AK) on barley seedlings. Isolates of *R. solani* AG-8 were all pathogenic on wheat, and seedling stunting and root rot were usually more severe at lower than at higher temperatures. An Australian scientist found that the virulence of *R. solani* AG-8 was higher on barley than wheat. In the Pacific Northwest, root rot is more damaging to barley than to wheat in side-by-side plantings. Studies continue to demonstrate that relationships are complex between soil temperature and specific isolates of each species and group of *Rhizoctonia*.

Seed Rot, Seedling, and Stem Diseases

Seed rot and preemergence damping-off of wheat and barley are caused by *R. oryzae* and *R. cerealis*. Isolates of *R. cerealis* from wheat following bluegrass seed crops reduce wheat emergence as much as 40 percent in greenhouse experiments. In contrast, isolates of *R. solani* AG-4, AG-5, and AG-8, that cause severe root rot of cereals, do not affect seedling emergence.

Sharp eyespot, caused by *R. cerealis,* is characterized by development of circular to elliptical lesions on the leaf sheath near the base of wheat and barley stems. Symptoms are very similar to those by strawbreaker foot rot (also named “eyespot”), caused by *Pseudocercosporella herpotrichoides*. Sharp eyespot becomes more prevalent and recognizable as fungicides and resistant cultivars are introduced to control strawbreaker foot rot. Although sharp eyespot typically results in minimal yield loss, infections that extend through the stem tissue can result in blight of seedlings or lodging of mature plants. Severe damage from sharp eyespot has been observed on winter wheat following bluegrass harvested for sod in New York state.

R. cerealis can be particularly damaging when wheat follows grasses in a rotation. Winter wheat cultivars appear to differ in susceptibility to infection by *R. cerealis*, but reliable guidelines are not available.

MANAGEMENT OF ROOT ROT

Cultivation and Crop Residue Management

Rhizoctonia root rot of wheat and barley is usually more severe when the crop is sown directly into cereal stubble ("direct drill" or "no-till") than when planted into a seedbed prepared using conventional cultivation practices. Conventional primary tillage, either with a moldboard or chisel plow, has been the primary means used to control Rhizoctonia root rot of cereals. The incidence and severity of root infection is often inversely correlated with intensity and depth of cultivation. In Oregon, root rot on wheat after summer fallow increased with the amount of residue on the soil surface at the time of planting, and was reduced by burning wheat stubble before planting. Interestingly, root rot was unaffected by amounts of residue or tillage in a wheat-pea rotation that had a much higher microbial diversity and biomass than is present in wheat-summer fallow rotations.

Inoculum of *Rhizoctonia* in fields planted without tillage is concentrated in the upper four inches of the soil profile. Moldboard plows can bury the fungus propagules so the seedling wheat or barley roots do not encounter a high density of inoculum until the seedling has established an extensive root system. Burial of residue deeply and completely may be very beneficial for reducing root rot. Shallow or incomplete inversion of soil may be ineffective because some residue is placed in the zone where seedling roots from the next crop will contact the inoculum soon after the seed germinates.

Seed drills differ greatly in the amount of soil disturbance created during direct drilling. Increasing the depth and intensity of soil disturbance under the seed placement zone while drilling can increase wheat yields even in the absence of *Rhizoctonia.* However, disease can be particularly prevalent and damaging when root growth is inhibited by dense soil structure. Deep disturbance while planting appears to be as effective as pre-planting cultivations for reducing damage from Rhizoctonia root rot. It is now accepted that direct drilling with openers that disturb soil below the seed reduce damage from Rhizoctonia root rot and take-all. Similar benefits are achieved by installing either a chisel point or coulter in front of each drill opener to loosen soil and move infested residue away from the narrow zone where seedlings will establish.

Crop Rotation and Disease Decline

Isolates of *R. solani* pathogenic to wheat also infect crops such as peas, lentils, lupins, and canola. Despite the broad host range of these fungi, crop rotation is an effective means to reduce the incidence of root rot of wheat and barley. Reduced root rot in wheat-pea rotation, compared to wheat-fallow or wheat-canola rotations, is thought to occur in response to greater microbial biomass and/or diversity in the wheat-legume rotation, thereby limiting the inoculum potential of the pathogen. Although crop rotation may afford some protection against Rhizoctonia root rot by lowering the inoculum potential of the pathogen, rotation can only provide significant control of this disease when wheat or barley follows several years of plant-free fallow.

While rotations often reduce severity of Rhizoctonia root rot in short-term experiments, there is growing evidence that disease severity also declines under long-term cereal monoculture (e.g., annual cropping). A disease decline phenomenon for root rot caused by *R. solani* AG-8 was described at Pendleton. Similar observations have been made for take-all of annual spring- or fall-planted wheat and barley, and for *Rhizoctonia* diseases of sugarbeets or radishes grown continuously. Studies at two Umatilla County locations showed that productivity of barley in *Rhizoctonia*-infested soil increased with number of years of no-till management. When the annual no-till system was initiated there was a sharply defined initial increase in root rot severity and a concurrent decline in yield, followed by a return to "normality" as the numbers of years of annual cropping increased. Studies with continuous cropping elsewhere have shown that the decline in disease and increase in yield occurs when all plant residue is re-incorporated into the soil, but not when the residue has been removed, as by burning or straw removal. Suppression of Rhizoctonia root rot has been associated with an abundance of earthworms in some studies, and earthworms are known to be most active in conservation tillage systems.

Disease decline phenomenon appear to be associated with increased biological activity in the soil, resulting from annual inputs of organic matter from cereals. The factor responsible for suppressing the disease in long-term monocultures can be transferred from one soil to another by simply transferring small amounts of soil from the disease-suppressive soil (e.g., the monoculture) to the nonsuppressive soil (e.g., soils cropped as rotations). The suppressive activity is eliminated when soil is partially sterilized by pasteurization or irradiation, suggesting that the suppressive factor is associated with living soil microorganisms. As such, this is a biological control system for root diseases.

Management of Volunteer Cereals and Weeds

Volunteer cereals and grass weeds serve as hosts of *R. solani* between the harvesting of one crop and the planting of the next. Root rot in no-till wheat and barley is most severe if planting is within 3 days after herbicides have been applied. Application of glyphosate (Roundup®) or paraquat at least 2 or 3 weeks before planting greatly reduces the severity of Rhizoctonia root rot and increases the yield of no-till wheat and barley. Compared to an application three days before planting spring barley, yields have been improved up to 20 percent by spraying three weeks before planting, and up to 50 percent by spraying in the fall as well as the spring. The longer interval between herbicide application and planting apparently allows additional time for saprophytic microorganisms to displace *Rhizoctonia* in the dying roots of treated plants, resulting in lower inoculum levels of the pathogen. Similar benefits also occur with root diseases caused by other pathogens.

Damage from Rhizoctonia root rot has been amplified on wheat and barley in soils treated with pre-plant or post-emergence applications of sulfonylurea herbicides such as chlorsulfuron (Glean®). These herbicides can cause plant stress, which enables *R. solani* to cause greater damage to wheat and barley roots in treated soils.

Seed Treatment

Many chemical and biological seed treatments have been evaluated for controlling Rhizoctonia root rot. Triadimenol (Baytan®) is effective in controlling infection of wheat by *R. solani* AG-4 but not *R. solani* AG-8. Tolclofos-methyl (Rizolex®) and flutolanil (Moncut®) are toxic to *R. solani* AG-8 and *R. oryzae,* and reduce the incidence of Rhizoctonia root rot on winter wheat seedlings, but seldom improve grain yields. Difenoconazole (Dividend®) in combination with the biocontrol agents *Pseudomonas fluorescens* Pf-5; *Pseudomonas chlororaphis* 30-84, or *Bacillus* sp. L324 reduce damping-off and root rot of wheat seedlings caused by several *Rhizoctonia* species, but are more active against *R. oryzae* and *R. cerealis* than *R. solani* AG-8. Development of consistently effective seed treatments will be difficult due to the multiple species of *Rhizoctonia* capable of causing disease on cereals, the differential sensitivity of these pathogens to fungicides and antibiotics produced by biological control agents, and the prolonged period during which winter cereals remain susceptible to damage by *Rhizoctonia* species. Disease protection and positive yield responses to fungicide seed treatments are more prevalent for spring- than fall-planted cereals, presumably because protection remains higher over a longer proportion of the plant growth cycle for spring- than fall-planted cereals.

Plant Nutrition

There are numerous reports of plant growth responses to application of nitrogen fertilizer in *Rhizoctonia*-infested soils. Results have varied from suppression to no effect, or even increased damage. Inorganic sources such as ammonium nitrate have led to higher amounts of damage than from organic sources (pea vines or cow manure) in long-term (60-year) experiments at Pendleton. Elaborate evaluations of wheat responses to nitrogen in soils infested with *R. solani* AG-8 at other locations have led to the conclusion that nitrogen alone has no effect on root damage. Zinc deficiency in Australia reduces host resistance to *R. solani* AG-8 and increases damage to roots of wheat and barley, but this is not known to occur in the Pacific Northwest.

Strong advantages are usually achieved when balanced fertilizers are banded directly below the seed, and sometimes when mixed with the seed. The placed fertilizer is immediately available and improves seedling vigor much more than when fertilizer is broadcast or injected prior to planting. Banding a balanced starter fertilizer is particularly well suited for use with drills that loosen soil below the seed zone.

Host Plant Resistance or Tolerance

Wheat and barley cultivars tolerant to Rhizoctonia root rot are not available even though cultivars and breeding lines vary significantly in tolerance to root damage. For example, at both Pendleton and Moro, five of 216 lines yielded nearly as well in soil artificially inoculated with *R. solani* AG-8 as in adjacent plots where the pathogen had not been added. Unfortunately, development of cultivars with acceptable levels of tolerance is still impeded by high season-to-season and field-to-field variability.

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